

# The Effect of Biofeedback on Coping for Patients with Depression

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THE EFFECT OF BIOFEEDBACK ON COPING FOR PATIENTS WITH DEPRESSION

by

AMBER ATKINSON

A thesis submitted in partial fulfillment of the requirements  
for the Honors in the Major Program in Nursing  
in the College of Nursing  
and in The Burnett Honors College  
at the University of Central Florida  
Orlando, Florida

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Thesis Chair: Dr. Cherrill Stockmann

## **ABSTRACT**

**Background:** Individuals with depression have a higher incidence of comorbidity which significantly decreases their ability to function and increases their utilization of health care. Due to the severity of the economic burden resulting with depression, research is needed to further examine the most effective treatments for depression. Biofeedback is a therapy that teaches patients how to control the physical affects that manifest during depression.

**Aim:** The purpose of this review of literature is to discover the benefits of biofeedback for patients diagnosed with depression.

**Method:** An electronic literature search was conducted using various databases to retrieve articles examining biofeedback as an intervention for patients with depression or depressive symptoms.

**Results:** Studies that used biofeedback as an intervention for depression reported significant physical benefits for patients, including decreased heart rate variability and respiratory rate, as well as improved function.

**Conclusion:** Research indicates that treatments need to have the potential to empower individuals, relieve them of their negative symptoms, relieve their financial burden, and allow them the quality of life they deserve.

## **DEDICATION**

For my family and friends who have supported me every step of the way. Thank you for never letting me give up, slow down, or be discouraged.

## **ACKNOWLEDGEMENTS**

I first and foremost give thanks to God, who has called me to declare his hope throughout the nations. It is with His strength and purpose that I have produced this research.

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## **INTRODUCTION**

Depression is one of the leading causes of disability in the United States and affects a staggering 350 million people worldwide (World Health Organization [WHO], 2016). The impact of depression is not only concerning because of the amount of people who suffer with sadness, hopelessness, and physical symptoms, but it is troubling because, out of those 350 million people, many of them will attempt suicide. In 2013, the Centers for Disease Control and Prevention (CDC) revealed that 41,149 people died in the United States as a result of suicide (CDC, 2016).

Depression negatively impacts the quality of life and is often accompanied by other chronic illnesses (CDC, 2014). Patients with depression have a higher incidence of comorbidity, which significantly decreases their ability to function and, in turn, increases their health care utilization (CDC, 2014). Common mental health comorbidities occurring with depression include panic disorder, substance-related disorders, obsessive-compulsive disorder, anorexia nervosa, bulimia nervosa, and borderline personality disorder (APA, 2013). In addition, depression may complicate other comorbid conditions, such as heart disease, chronic obstructive pulmonary disease, inflammatory bowel disease, diabetes, and cancer (Katon, 2003).

Decreased work performance is associated with the increased health care needs resulting with depression (Wang, Simon, & Kessler, 2003). Fatigue, anergia, difficulty concentrating, impaired decision making, and social isolation resulting from depression significantly decreases work productivity (NIMH, 2015; Wang, Simon, & Kessler, 2003). Individuals with depression require considerably more disability days than those individuals who are not depressed, placing significant economic burden on both the individual and the economy as a whole (Greenburg,



Fournier, Sisitsky, Pike, & Kessler, 2015). In 2010, the economic burden placed on individuals with depression was an estimated \$102 million dollars of workplace costs (Greenburg et. al, 2015). Due to the severity of the economic burden resulting with depression, research is needed to further examine the most effective treatments for depression.

## **PROBLEM**

Current therapies that teach patients how to self-regulate symptoms of depression through cognitive strategies focus on mental awareness to promote effective coping (Beal, 2014).

Biofeedback teaches patients to focus their attention on the biological manifestations of depression, such as decreased Heart Rate Variability (HRV), increased respiration rate, and slow cortical potentials (Karavidas et al., 2007). When combined with alternative therapies, such as group sessions, meditation, and physical activity, biofeedback has the potential to holistically benefit patients learning to effectively cope with depression. Cost-effective treatments that empower individuals and provide symptom relief will promote their quality of life. A review of the literature will promote understanding of the possible benefits of biofeedback for patients diagnosed with depression.

## **PURPOSE**

The purpose of this review of literature is to discover the benefits of biofeedback for patients diagnosed with MDD. Further understanding is needed concerning the use and efficacy of biofeedback therapy for clients with MDD. Literature was reviewed concerning how biofeedback is used to treat the symptoms experienced by patients with MDD, the benefits of effective coping, and to provide recommendations for further research.

## **METHOD**

An electronic search was conducted to retrieve research articles on the use of biofeedback to help patients effectively cope with depressive symptoms. Databases used to locate research articles included CINAHL Plus with Full Text, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, MEDLINE, PsycARTICLES, and PsycINFO. Key terms were broken up into three search bars in the order of, (MH "Depression") OR Depress\*, in the first search bar, AB biofeedback OR TI Biofeedback, in the second search bar, and (MH "Coping") OR Coping OR cope OR stress manag\* OR anxiety manag\*, in the third search bar. Each of these searches were separated by, "AND," in order to find each detailed search within the articles. Inclusion criteria for an article included research that focused on biofeedback as an independent variable and the outcomes of coping, stress, and/or depressive symptoms, including anergia, anhedonia, and social isolation. Articles were excluded if the progression of depression symptoms was not analyzed. The only limiter placed on the initial search was "English language" in order to obtain more articles. The first search brought up 170 articles. Then after examining the titles for inclusion, there were 27 articles. After the abstract review looking further into the criteria, 11 articles were left. Then, after examining the complete articles, eight studies were left that matched the inclusion criteria for what this review sought to discover.

## **BACKGROUND**

### Depression

Depression may manifest in multiple forms. The Diagnostic and Statistical Manual of Mental Disorders (DSM-V) classifies depressive disorders based on the individual's clinical presentation. Depressive disorders may include Major Depressive Disorder (MDD), Persistent Depressive Disorder (dysthymia), Disruptive Mood Dysregulation Disorder, and unspecified depressive disorder (American Psychiatric Association [APA], 2013). Criteria used to determine the appropriate psychiatric diagnosis differ in relation to time, duration, and presumed etiology (APA, 2013). Traits, or specifiers, that differentiate depression further include anxious distress; mixed features; melancholic features; atypical features; mood-congruent psychotic features; mood-incongruent psychotic features; peripartum onset; catatonia, and seasonal patterns (APA, 2013). Following accurate diagnosis, treatment will be determined based on that individual's healthcare situation and needs. These treatments usually consist of medication, psychotherapies, and electroconvulsive therapy (ECT).

#### *Major Depressive Disorder*

Major Depressive Disorder is one of the most common mental disorders in the United States, but its effects extend beyond psychological symptoms (National Institute of Mental Health, 2016). Disorders involving depression can be severely debilitating for memory, attention span, role functioning, and it can increase fatigue during tasks that used to be easy (APA, 2013; Centers for Disease Control and Prevention [CDC], 2014). As a result of such debilitating symptoms, the healthcare impact is considerable. The financial burden may be equally debilitating.

### *Symptoms of Major Depressive Disorder*

A patient diagnosed with MDD will have displayed at least five symptoms signifying a change in their normal functioning for two weeks or more (APA, 2013). These symptoms include: depressed mood for much of the day, anhedonia, significant weight fluctuations, insomnia, hypersomnia, severe energy loss, feelings of guilt, feelings of lacking worth, decreased concentration and ability to make decisions, memory impairment, and continuous thoughts of harming oneself (APA, 2013). The physical symptoms of anergia, memory impairment, and decreased concentration illustrate how depression may be addressed through therapies that address more than just a target behavior or thought. It would be beneficial to know what types of biofeedback might also address the fatigue and decreased cognition resulting with depression.

### *Autonomic Nervous System*

The autonomic nervous system (ANS) has also been affected by the physiological changes resulting with depression (Kreibig, 2010). The involuntary controls regulated by the ANS can be categorized into either the parasympathetic nervous system (PSNS) or the sympathetic nervous system (SNS) (Olson, 2014). The PSNS creates a calming effect on the body by causing physiological events such as slowed heart rate, increased intestinal peristalsis, increased endocrine activity, and relaxed sphincters (Mosby, Inc., 2009). Naturally, the SNS has the opposite effect on the body and causes an increase in heart rate, blood vessel constriction, and increased blood pressure (Mosby, Inc., 2009).

### *Heart Rate Variability*

Collectively the ANS has influence over cardiac muscle cells, smooth muscle cells, and glands (Olson, 2014). More specifically, heart rate variability (HRV) has been used as a tool to measure the adaptability of the cardiovascular system under the influence of depression (Karavidas, 2007). When body systems regulated by the ANS showed negative changes, it was

evident that depression causes high sympathetic arousal to the point where stressors can no longer be addressed through a sympathetic response (Karavidas, 2007). Therefore, increased heart rate and decreased HRV for people with depression is associated with a prolonged increase in SNS activation (Kreibig, 2010; Vasudev, Cha, & McIntyre, 2015).

### Therapeutic Interventions

Clinical practice guidelines developed by the National Institute for Health and Care Excellence [NICE] (2009), the Institute for Clinical Systems Improvement (2016), and the American Psychological Association (2010) address the healthcare needs of clients with depression. These treatments may consist of pharmacotherapy, variations of cognitive behavioral therapy, and structured group programs (NICE, 2009). Although these recommended interventions provide many benefits for patients, guidelines still fail to acknowledge biofeedback therapies as treatment options to help patients control the possible physical manifestations of depression.

#### *Cognitive Behavioral Therapy*

Cognitive Behavioral Therapy (CBT), when combined with supplemental treatment, has the potential to enhance coping in depression (Parikh et al, 2016). CBT is a therapy commonly used in the treatment of depression. CBT teaches patients how to recognize negative thought processes and how to incorporate better strategies for effective coping and stress management (National Association of Cognitive-Behavioral Therapists [NACBT], 2016). Parikh et al. (2016) found that CBT that was paired with antidepressants decreased the likelihood of a depressive relapse by 20%. This finding should be researched further to discover whether or not CBT would also be enhanced by the addition of biofeedback therapy.

### *Neurofeedback*

The effects of neurofeedback, a version of biofeedback therapy, for patients with MDD were examined by Cheon, Koo, and Choi (2016). Neurofeedback specifically focuses on information that is generated by the nervous system rather than information that comes from the heart, lungs, muscles, or temperature; which is referred to as biofeedback. This prospective, open-label study was conducted to examine the effects of left prefrontal beta with alpha/theta training on depression. Results indicated that neurofeedback therapy was effective in improving depression symptoms, anxiety symptoms, and clinical illness severity for study participants (Cheon et al., 2016). Due to its positive effects for that sample, further consideration of biofeedback for clients with a primary diagnosis dealing with depression is needed.

### Biofeedback

Biofeedback is a therapy that has been primarily used for tension headaches, chronic pain, spasmodic torticollis, temporomandibular joint dysfunction, ADHD, and epilepsy (Frank, Khorshid, Kiffer, Morayec, & McKee, 2010). Various forms of biofeedback are used to monitor and adjust heart rate, respirations, muscle tension, and temperature at the skin surface in order to help control the aforementioned ailments (Frank et. al, 2010; Mackay, Buckingham, Schwartz, Hodgkinson, Beran, & Cordato, 2015). A trained professional conducts an initial assessment with the patient to determine their needs and individualize their plan of care. Two forms of biofeedback commonly used include surface electromyography (sEMG) and Electroencephalography (EEG) (Frank et. al, 2010). Surface electromyography (sEMG) is the physiologic form of biofeedback that is most commonly used; while electroencephalography (EEG), also known as neurofeedback, helps with disorders that are caused by and focus on the nervous system (Frank et. al, 2010). Once an intervention is chosen, the patient is connected to a



monitor that displays a visual representation of their physical status. This visual image shows a change in such physiological symptoms as heart rate and respirations. The patient is then able to work with the health care professional to learn to control their physical symptoms. Watching the image on the screen helps the patient determine which symptoms are felt with each type of intervention. This therapy teaches patients ways to control their body, so that one day they will be able to self-regulate independently. Patients who are encouraged to participate in biofeedback therapy use it as an alternative or adjunctive therapy alongside medications and other forms of therapy (Frank et. al, 2010).

Treatment guidelines for depression presently lack sufficient research and consideration for biofeedback therapy as an intervention for MDD. Health care providers should seek how biofeedback therapy, as a sole or supplemental treatment option, could benefit their patients experiencing depression. The roles of patient advocate and educator would be strengthened through nurses' understanding of biofeedback as a therapeutic intervention. Biofeedback therapy complements holistic nursing care by addressing the psychological and physical needs of patients.

### Summary

All in all, this literature review is important for discerning whether or not everything is being considered when it comes to treating patients with depression. Due to the nature of depression's effect on ability to work, exercise tolerance, memory, creating reliance on long term therapies, and more, further research is needed to investigate multiple treatment options that could address some of the symptoms more appropriately.

## **RESULTS**

The majority of studies retrieved with this review of the literature were experimental designs, including two quasi experimental studies (Staples, Abdel Atti, & Gordon, 2011; Tan et al., 2013) and four randomized controlled trials (Swanson et al., 2009; Klimov et al., 2014; Kotozaki et al., 2014; Zwan, Vente, Huizink, Bögels, & Bruin, 2015). The remaining studies were a cross-sectional study (Nahshoni et al., 2004) and a systematic review (Canadian Agency for Drugs and Technologies in Health, 2014), which used two checklists to analyze the quality of research. The sample sizes in this review ranged from three to 129. Two studies were conducted in the United States and the remaining studies were conducted in Israel, Gaza, Belgium, Canada, Japan, and the Netherlands. Including studies from various countries improves the ability to apply this information across cultures, supporting cultural sensitivity.

The primary intervention examined in this body of literature was biofeedback, but supplemental treatments including breathing retraining, mind-body skills sessions, clinical video-conferences, and a rehabilitation program were also studied (Swanson et al., 2009; Staples et al., 2011; Tan et al., 2013; & Klimov et al., 2014). The majority of studies measuring biofeedback, measured HRV (Nahshoni et al., 2004; Swanson et al., 2009; Klimov et al., 2014; Zwan et al., 2015). Swanson et al. (2009) examined HRV biofeedback with respiration training. Two studies included biofeedback that measured temperature and cerebral blood flow with the heart rate (Staples et al., 2011; Kotozaki et al., 2014). Three studies out of the seven that used biofeedback also used breathing retraining as an intervention (Swanson et al., 2009; Staples et al., 2011; Tan et al., 2013). Patient outcomes examined in relation to the use of biofeedback and

other alternative treatments were classified according to physical symptoms, psychological symptoms, or both.

Despite the diversity among this literature, each of these studies reported evidence indicating that biofeedback was a useful intervention for the physical symptoms of depression. In addition, supplemental or holistic interventions were useful interventions for the psychological symptoms of depression. Research showed that biofeedback alone does not have enough supporting evidence to be considered as a solitary treatment option for patients with depression. Yet, research did show that biofeedback that is paired with another type of intervention, such as mind-body skills sessions, guided imagery, or meditation, may meet both the psychological and physical needs experienced with depression.

### Depression

Research findings showed significant changes in physical and/or psychological depressive symptoms in five out of the eight studies retrieved in this review. The dependent variables that dealt with depression and its symptoms were observed and measured as physical symptoms, psychological symptoms, or both. Much like the purposes of this group of studies, the outcomes reflected what the researchers aimed to discover. Variables addressing physical symptoms included HRV, exercise tolerance, systolic and diastolic blood pressures, salivary cortisol levels, and cerebral blood flow (Nahshoni et al., 2004; Swanson et al., 2009; Klimov et al., 2014, Kotozaki et al., 2014). The psychological variables included quality of life; symptoms associated with post-traumatic stress disorder (PTSD); depressive symptoms; hopelessness; pain intensity and unpleasantness; sleep disturbance or quality; anxiety; type D personality, and psychological well-being (Swanson et al., 2009; Staples et al., 2011; Tan et al., 2013; Klimov et al., 2014; Canadian Agency for Drugs and Technologies in Health, 2014; Kotozaki et al., 2014;

Zwan et al., 2015). Following data analysis, it was evident that none of the studies focused only on depression, revealing a gap in the literature concerning evaluation of biofeedback specifically for patients with depression. Instead, this body of literature mainly evaluated depression and its symptoms in addition to other psychological symptoms.

After analyzing the literature, the negative psychological symptoms of depression were relieved when biofeedback was combined with other holistic treatments. For example, Tan et al. (2013) evaluated an innovative treatment for women veterans who suffer from chronic pain and/or depression associated with trauma. The authors found that depression was significantly improved after women veterans participated in six weeks of home use with a biofeedback device called the Stress Eraser (SE) and weekly clinical video-teleconferences. Statistically significant improvements were found in pain unpleasantness, pain interference, depressive symptoms, PTSD symptoms, and sleep disturbance. Improvements appeared to be maintained at 6-week follow-up. Frequency of SE use was significantly associated with decrease in distressed mood and decreased anxiety, while SE points obtained was significantly associated with decrease in distressed mood (Tan et al., 2013). Most importantly, these improvements persisted after a follow-up analysis six weeks later.

Nahshoni et al. (2004) conducted a study to measure the cardiac autonomic imbalance in patients with MDD, hypothesizing that the HRV measures of patients with MDD would be higher than those of the heart transplant recipients (who have denervated hearts) but lower than those of the healthy comparison subjects. The mean interbeat interval and mean pointwise correlation dimension (PD2) values for both the MDD and heart transplant groups were similar and significantly lower than the control group. There was no significant difference between the

MDD group and the transplant group with HRV, but there was a significant difference between those groups and the healthy participants. Both the MDD and transplant groups had significantly less HRV than the control group (Nashoni, 2004).

Zwan et al. (2015) found that physical activity created more improvement over biofeedback in stress, anxiety, depression, sleep quality, and psychological well-being. Participants in this study were assigned to one of three groups that either did physical activity, mindfulness meditation, or heart rate variability biofeedback for five weeks, and heart rate variability biofeedback was the intervention that showed the least improvement in psychological well-being (Zwan et al., 2015). Klimov et al. (2014) combined HRV Biofeedback with a supplemental rehabilitation program to increase the cardiac coherence level in coronary artery disease (CAD) patients. There were no statistically significant differences between the control group and the biofeedback group in the evolution of the systolic or diastolic blood pressure values over the course of the study. Most patients in the biofeedback group were able to increase their cardiac coherence percentage significantly. These results reveal that when only looking at the psychological elements of depression, biofeedback should be paired with another holistic intervention in order to experience significant improvement.

#### Therapeutic Interventions

Among the eight articles examined in this literature review, four articles addressed quality of life and psychological symptoms. Nahshoni et al. (2004) sought to investigate the physical effects of biofeedback and three articles sought to accomplish both of the aforementioned purposes (Swanson et al., 2009; Klimov et al., 2014; Kotozaki et al., 2014). The greatest number of independent variables being studied at once came to a total of eleven interventions (Staples et al., 2011), which negatively impacted the ability to clearly identify its

effect, if any, on depression. Nahshoni et al. (2004) examined only one intervention, which provided a clearer view of that intervention's impact on patient outcomes. Studying such a large number of interventions alongside biofeedback negatively impacts the ability to single out its singular effect on depression.

Independent variables used in the research articles mostly included biofeedback as a supplemental treatment alongside other interventions. Three studies out of the seven that used biofeedback also used interventions of breathing retraining (Swanson et al., 2009; Staples et al., 2011; Tan et al., 2013). These interventions often occur together due to the influence that reduced respirations have on the parasympathetic system, which controls relaxation and counteracts the overstimulation of the sympathetic system that can occur in depression (Swanson et al., 2009).

Studies that used supplemental interventions alongside biofeedback showed the most well rounded improvement of body and mind. For example, Staples et al. (2011) used supplemental interventions to determine if the mind-body techniques could be effective for a broad range of patients regarding age and cultural background. The authors also studied the effect of the program on depression symptoms. After 10 sessions of the joint interventions, participants reported decreased symptoms of PTSD and depression. A highly significant effect was shown with time for PTSD, indicating that higher baseline scores resulted in greater improvements in PTSD and the cluster symptoms following the intervention. A significant effect was found with time on total depression scores and the subscales. Older children had more improvement in avoidance scores from baseline to follow-up and girls' scores remained significantly lower than boys at follow-up. Pairwise controls showed that the overall PTSD score and cluster symptom

scores significantly improved following the mind-body skills groups. Significant age-by-time interaction was observed for the total depression score; negative self-esteem; interpersonal problems; anhedonia; and negative self-esteem indicating that improvements in depression and these subscales from baseline to follow-up were greater for older children. Overall depression and subscale scores significantly improved post-intervention and were fully maintained at follow-up for interpersonal problems, negative self-esteem, and ineffectiveness subscales. In addition to revealing the value of using multiple types of therapeutic interventions, research also proved that those who participated the most in these interventions, experienced the best results.

Zwan et al. (2015) compared the effects of self-directed PA, MM, and HRV-BF on perceived stress, anxiety, depression, sleep quality and psychological well-being in adults with stress complaints. The significance of the changes experienced from the interventions depended on how compliant the participants were during the five weeks of treatment. Participants who trained for approximately 70% of the prescribed time indicated that greater compliance is associated with larger effects of the interventions. The intervention group reported slightly better sleep quality at pretest than the dropout group. Stress, anxiety, depression, sleep quality, and psychological well-being all changed significantly in the expected direction over time. The PA intervention yielded the largest effects. MM was the only intervention that improved sleep quality (Zwan et al., 2015).

### Biofeedback

Intervening with the use of biofeedback proved to be very beneficial for the physical effects of depression, such as cardiovascular health, cortisol levels, and the respiratory system. Among the seven studies that used biofeedback as in intervention, it was found that the most

popular type of biofeedback intervention measured physical data from the heart. More specifically, biofeedback that measured HRV was used in 5 out of those 7 studies. The remaining two studies included biofeedback that measured temperature, and cerebral blood flow and heart rate (Staples et al., 2011; Kotozaki et al., 2014). Rather than causing significant improvement with the psychological aspect of depression, biofeedback proved to significantly improve the physical comorbidities that occur as a result of depression.

Patients with MDD had very similar heart rate variability to those who had a heart transplant (Nahshoni et al., 2004). These results provide a clear example of how depression has a negative effect on the autonomic nervous system, which in turn negatively affects the cardiovascular system. Patients who had a heart transplant served as a comparison group of denervated hearts to help prove the hypothesis that the cardiovascular imbalance of patients with depression mirrors that of patients with heart diseases, which has great implications for how interventions should be chosen for patients with depression (Nahshoni et al., 2004).

A decrease in HRV resulting from autonomic dysfunction has been known to increase morbidity, mortality, and a poor prognosis for patients (Swanson et al., 2009). Swanson et al. (2009) conducted research to examine the effects of a six week course of cardiorespiratory biofeedback on exercise tolerance, HRV, and quality of life. Participants were selected based on their medical status of heart failure and depression. There was a significant difference in the high vs. low left ventricular ejection fraction (LVEF) in the control groups in relation to fatigue. HRV biofeedback does not appear to be helpful for people with more severe disease, but was helpful for people with milder disease. At the end of the study, they found that depression and quality of life were not positively changed by the interventions. The treatment group had a higher increase



in meters walked than did the control group, indicating an improvement for exercise tolerance (Swanson et al., 2009). Even though there were no significant changes for the psychological symptoms of depression in this study, the physical benefits are an aspect of care that should not be ignored when treating these patients.

Kotozaki et al. (2014) investigated the anatomical correlates of biofeedback effects and the psychological changes associated with those effects. Before and after four weeks of either biofeedback sessions or no intervention, participants were measured for level of depression, positive and negative effects, job stress, cortisol levels in saliva, and cerebral blood flow. The biofeedback group displayed a significant decrease in depression scores, positive and negative affect scores, and job stress. Salivary cortisol levels significantly decreased after the biofeedback intervention, while regional gray matter variation (cerebral blood flow) increased (Kotozaki et al., 2014). These positive results showed that biofeedback was affective as an intervention in the face of daily hassles. Biofeedback was determined to be beneficial for two reasons. First, participants were learning how to use emotional self-control in their daily life, which in turn gave them more confidence to overcome stress from their jobs. Secondly, biofeedback enhanced the parasympathetic activity which led to the positive physical changes in heart rate, cortisol levels, and cerebral blood flow (Kotozaki et al., 2014).

## **DISCUSSION**

The literature reviewed demonstrated a consistent pattern of physical benefits from the use of biofeedback, and psychological benefits from alternative interventions. Long-term physical consequences of depression were relieved; however, this evidence has not been addressed through current treatment guidelines. Biofeedback therapy, when paired with an intervention that focuses on psychological symptoms, may result in significant health benefits for patients with long term depression, such as, MDD, after finding benefits in the studies conducted by Nahshoni et al. (2004) and Zwan et al. (2015).

The physical manifestations of depression reported by Karavidas et al. (2007), which included decreased HRV and increased respiratory rate, were supported by this research (Nahshoni et al., 2004; Swanson et al., 2009; Staples et al., 2011; Klimov et al., 2014; Zwan et al., 2015). Each of these five studies measured HRV and respiratory rate in an effort to correct the negative impact of depression on physiological function. These studies support the findings reported by Karavidas et al. (2007) concerning how depression affects HRV and respiratory rate. This evidence further supports the use of biofeedback as a therapeutic intervention to address those physical effects.

Including biofeedback, specifically cardiovascular related biofeedback, into the treatment regimen for patients with depression has the ability to help decrease the effect that comorbid cardiac diseases may have on the body (Nahshoni et al., 2004). Reducing the effect of cardiovascular comorbidities will also reduce the amount of money that these patients are spending on health care, and increase their time and ability to work. A dual treatment approach for depression can provide the holistic treatment that these patients have been lacking. With

guidelines that only include interventions like pharmacological treatment, cognitive behavioral therapy, and group therapy sessions, biofeedback provides the physical support that these patients need.

Cognitive behavioral therapy was not included in any of the studies examined for this literature review, but structured group therapies were examined alongside biofeedback. Pharmacotherapy was also used by some of the participants in the study conducted by Nahshoni et al. (2004), but was not a variable that they chose to control, and therefore cannot be assessed as being used in conjunction with biofeedback. Structured group therapies were the only type of current guideline intervention that appeared in this literature (Staples et al., 2011; Tan et al., 2013; Klimov et al., 2014). Staples et al. (2011) and Tan et al. (2013) found significant improvement for depression; however, Klimov et al. (2014) did not find significant improvements. None of the studies examined the use of neurofeedback to measure electrical impulses from the nervous system. Kotozaki et al. (2014) studied cerebral blood flow and heart rate with biofeedback and found significant changes in the blood flow to certain regions of the brain following biofeedback therapy.

As a result of neurofeedback and CBT not being included as interventions in these eight studies, it shows a lack of knowledge concerning neurofeedback and CBT alongside biofeedback. Which in turn, leaves a large gap in the knowledge about how those interventions could benefit a patient when paired together. Because of the research done by Cheon et al. (2016) and NACBT (2016), who found that neurofeedback and CBT show positive results as treatment for depression, it is necessary that future studies search for ways to enhance these interventions with the addition of biofeedback.

Empowering patients with information about how depression can affect the body, and teaching them how to control those affects through biofeedback, is a positive step in the direction towards improving their quality of life. After looking at the eight studies and finding that physical symptoms also play a large role in depression, it would be a beneficial next step to research how adding that type of intervention could be financially beneficial. The studies examined in this review did not focus on financial benefits that patients could experience while participating in the interventions, yet some of the improvements that the patients experienced could be found to benefit them financially. For example, in the study conducted by Swanson et al. (2009), they found that participants in the biofeedback group experienced significant improvement in distance walked. Such improvements in activity tolerance could increase a patient's ability to attend work, decreasing the amount of times they take sick days, which was a problem that Greenburg et al. (2015) found in patients with depression. In light of these conclusions, it is still necessary to perform studies to support the idea that there could be financial benefits to biofeedback.

However, it is necessary to stress that meeting the immediate psychological needs of a patient with depression is very important before biofeedback can be beneficial. A patient experiencing suicidal thoughts will most likely not change their mind by attending a biofeedback therapy session. Biofeedback should be used as a tool of empowerment and physical health for patients who are also receiving psychological support. Treating depression through the mind and body will greatly enhance the quality of life of those living with depression in a holistic way.

## **LIMITATIONS**

This literature review was limited by the lack of relevant articles dealing with biofeedback as a treatment for patients solely dealing with the diagnosis of MDD. Research studies that examined depression as a secondary or additional variable decreased this reviews ability to make conclusions about biofeedback's effect on depression alone. There were also no studies that sought to examine biofeedback as a supplemental treatment with pharmacotherapy, cognitive behavioral therapy, or electroconvulsive therapy. The absence of existent studies on these subjects reveals the need for future research to explore biofeedback paired with the treatments that are current guidelines for depression management.

Limitations that impacted the effectiveness of the included studies were: small sample sizes, limited generalizability, participant drop out, incomplete data, limitations of study design, uncontrolled variables, unconsidered chronic illnesses, follow-up information that was absent or not long enough, and lastly, a lack of finances. Each study experienced at least one of these limitations. The most common limitation experienced throughout the studies was a small sample size. Small sample sizes limited the ability for conclusions to be made concerning the majority of the population, so biofeedback cannot be said to cause results in every patient with depression.

Including studies from multiple countries in this review was a strength that gave credibility to the possible impact of depression in different cultures. Yet, the review was limited by the studies that used participants of one gender (Tan et al., 2013; Klimov et al., 2014; Kotozaki et al., 2014) or had one gender outnumber the other (Staples et al., 2011).

These limitations should be addressed when conducting future research to enhance the credibility and relevance of the study for all people struggling with depression.

## **RECOMMENDATIONS**

Biofeedback therapy for patients with depression or depressive symptoms has proven to be beneficial on the autonomic nervous system, which in turn improves the regulation of the cardiovascular system. These benefits, however, were enhanced when paired with an intervention that met the psychological needs of participants. Although, in order to apply these results to patients who only have MDD, and not a comorbid psychological or physical ailment, future research needs to be conducted excluding participants with comorbid ailments.

Future research also needs to include studies that examine the effects of biofeedback when paired with current guidelines for the treatment of depression. There are currently no studies that focus on biofeedback paired with cognitive behavioral therapy, pharmacotherapy, electroconvulsive therapy, or others that are considered for treatment. In order for biofeedback to be considered as a viable option for supplemental treatment with depression, these types of studies need to be conducted.

It would also be particularly beneficial to incorporate the study of biofeedback on depression into a longitudinal study. Knowing the effects of this type of therapy over months to years would greatly increase how it is used in patients with MDD, since they suffer with depression chronically.

Before recommending the use of biofeedback to patients with depression, it is paramount that health care providers analyze the patient's ability and self-motivation to follow through with the intervention. As previously stated, unaddressed suicidal or homicidal thoughts need to be managed with another treatment before using biofeedback therapy in their regimen.

Biofeedback, however, should be considered for patients seeking an alternative therapy that addresses physical needs.

## **CONCLUSIONS**

Research tells us that when it comes to treating depression, there needs to be a multifaceted approach. This literature review found that the type of biofeedback being used most frequently in patients with depression, or depression symptoms, was HRV biofeedback. The cardiovascular system was the system that was being affected the most because of depression's effect on the autonomic nervous system. As a result of these findings, it is important to treat depression for both its psychological effects as well as its physical effects.

Studies do not currently have enough evidence to include biofeedback into the treatment guidelines for depression, but with future research, it has the potential to prove to be an aid in the physical needs of patients dealing with long term depression. Nursing practice should continue to look into the efficacy of biofeedback as an alternative treatment for their patients. When seeking to holistically care for those suffering with depression, nurses need to consider treatments that address more than just the negative psychological effects. Biofeedback therapy should be an intervention that patients are educated about, because it is the job of health care providers to empower patients with therapeutic choices available to help them cope and improve their quality of life. After all, patients deserve the very best that research and holistic treatments have to offer them, so that they can live their best life.



**APPENDIX A:**  
Figure 1

Relevant research articles that were identified after searching the databases of: CINAHL Plus with Full Text, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, MEDLINE, PsycARTICLES, and PsycINFO

(n = 170)

Included limiter of:  
English language

(n = 85)

Research articles underwent a  
review of their titles to meet  
inclusion criteria:

(n=27)

Research articles underwent an  
analysis of their abstracts for  
inclusion criteria and relevance to the  
study:

(n= 11)

Research articles were  
critiqued for reliability of  
evidence and necessary  
information:

(n = 8)

**APPENDIX B:**  
Table of Evidence

Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations
Nahshoni, Aravot, Aizenberg, Sigler, Zalsman, Strasberg, Imbar, Adler, & Weizman 2004 Petach Tikva, Israel	Cross-sectional design  The purpose of this study was to measure the cardiac autonomic imbalance in participants with depression, participants with post-heart transplants, and healthy participants	30 subjects  n = 10 inpatients who met the DSM-IV criteria for Major Depressive Disorder (MDD)  n = 10 non-hospitalized patients who had and orthotopic heart transplant  n = 10 physically healthy volunteers	ECG readings of HRV were taken for all three groups of participants.  The dependent variable in this study was the frequency of HRV	ECG recordings were gathered during spontaneous breathing for all subjects, patients with Major Depression, post-transplantation patients, and the healthy patients.  The time-domain measured the mean of the normal RR intervals (in msec) and the standard deviation of the entire recording (SDRR, in msec) were obtained for each data point	The mean interbeat interval and mean pointwise correlation dimension (PD2) values for both the MDD and heart transplant groups were similar and significantly lower than the control group.  There was no significant difference between the MDD group and the transplant group with HRV, but there was a significant difference between those groups and the healthy participants. Both the MDD and transplant groups had significantly less HRV than the control group.  The study was non-experimental. The sample size was small. The effect of the immunosuppressant drugs on the cardiac autonomic nervous system of the patients with post-transplantation is unknown. The SSRIs taken by the patients with depression may have affected their HRV
Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations
Swanson, Gevirtz,	2 (treatment vs. control) x	29 heart failure	Heart failure patients	<i>Pretreatment Measures:</i>	There were no significant baseline differences between the treatment and

<p>Brown, Spira, Guarneri, &amp; Stoletniy</p> <p>2009</p> <p>Loma Linda, CA</p>	<p>3 (pre, post, and follow-up) randomized, single-blind, controlled, factorial design with repeated measures.</p> <p>The purpose of this study was to discover if a 6 week course of cardiorespiratory biofeedback would increase exercise tolerance and HRV, and improve quality of life.</p>	<p>patients</p> <p>Group 1: (n = 15) Group 2: (n = 14)</p> <p>Participants were randomly assigned to either the treatment group (Group I) or the attention placebo control group (Group II)</p>	<p>underwent 6 weeks of heart rate variability (HRV) biofeedback, and breathing retraining.</p> <p>The study evaluated the effect of biofeedback on exercise tolerance, HRV, and quality of life.</p>	<p>Demographics Health Questionnaire</p> <p><i>Outcome Measures:</i> 6 Minute Walk Test; Borg Scale; Physiological Monitoring and Instrumentation (HRV measures, Electrocardiograph, Pneumograph magnetic strain gauge); Minnesota Living with Heart Failure Questionnaire; Positive and Negative Affect Scale (PANAS), and Center for Epidemiological Studies-Depression Scale.</p> <p><i>Other Measures:</i> Credibility/ Expectancy Questionnaire; Stress Management</p>	<p>control groups on demographic or clinical variables. Dyspnea approached significance between the two groups.</p> <p>There was a significant difference in the high vs. low left ventricular ejection fraction (LVEF) in the control groups in the area of fatigue.</p> <p>The treatment group had a higher increase in meters walked than did the control group. The difference was higher for participants in high LVEF category.</p> <p>An important finding was that HRV biofeedback does not appear to be helpful for people with more severe disease. It help people with milder disease.</p> <p>No relationship was found with depression, mood, amount of time practiced, level of dyspnea or fatigue, perception of credibility of treatment.</p> <p>33% of the treatment group displayed a clinically significant increase in distance walked between baseline and follow-up measures. While, only 12.5% of the control group demonstrated clinical significance in distance walked.</p>
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				and Exercise Practices Questionnaire; Medication Record; Practice Logs; Daily Stress Management and Exercise Record, and Vital Signs.	This study was limited financially and was unable to examine post or follow-up LVEF values. Due to attrition, the ability to evaluate participants who had a greater degree of negative mood, depressive symptoms, and reduced HRV. The small sample size limits the generalizability of the results. The study was also limited by time. A longer follow-up period was not possible and later improvements were not measured.
Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations
Staples, Atti, & Gordon 2011 Gaza	Randomized Controlled Trial  This study sought to evaluate mind-body skills groups that were led by 37 trained health and mental health professionals and educators.  The purpose	129 children and adolescents with Post-Traumatic Stress Disorder (PTSD)  There were 8-10 children in each group.	Mind-body skills sessions included deep breathing; drawing, temperature biofeedback and autogenic training, guided imagery, self-awareness body scan meditation, fast deep breathing followed by free movement to music, eating	The Child PTSD Symptom Scale (CPSS) was used to screen the children for PTSD symptoms.  The Children's Depression Inventory measured behavioral, cognitive, and affective symptoms with five subscales: total depression score, negative mood, interpersonal	There was a weak, but statistically significant correlation between baseline PTSD scores and exposure to military violence. A highly significant effect was shown with time for PTSD, re-experiencing, arousal, and avoidance, indicating that higher baseline scores resulted in greater improvements in PTSD and the cluster symptoms following the intervention.  A significant effect was found with time on total depression scores and the subscales.  Both age-by-time and sex-by-time interaction effects were significant.

	<p>of this study was to determine if the mind-body techniques developed by the Center for Mind-Body Medicine could be effective in a study with a broader range of age and different cultural background. They also wanted to see the effect of the program on depression symptoms, as well as in an area with ongoing conflict, threats, and stress.</p>		<p>meditation, genograms, and a dialogue with a symptom. PTSD, depression, and hopelessness were all evaluated after the completion of the mind-body sessions.</p> <p>10 sessions were held for two hours twice a week. Each session consisted of meditation, guided imagery, breathing techniques, autogenic training, biofeedback, genograms, and self-expression through words, drawings, and movement.</p>	<p>problems, ineffectiveness, anhedonia, and negative self-esteem.</p> <p>The Hopelessness Scale for Children (HSC) measured whether the sense of hope after the mind-body skills groups.</p> <p>Trauma exposure was measured using a checklist created by the clinical director.</p> <p>Data from children not meeting the PTSD criteria were not fully analyzed except to compare initial differences in exposure levels to military trauma with children meeting PTSD criteria and to</p>	<p>Older children had more improvement in avoidance scores from baseline to follow-up and girls' scores remained significantly lower than boys at follow-up.</p> <p>There was a significant effect of the baseline scores on the total depression score; negative mood; ineffectiveness; anhedonia; and negative self-esteem, indicating that higher baseline scores resulted in greater improvements in depression and all five subscales following the groups.</p> <p>For the avoidance cluster symptom, age effect was significant, implying that older children had more improvement in avoidance scores.</p> <p>Pairwise controls showed that the overall PTSD score and cluster symptom scores significantly improved following the mind-body skills groups. Yet, the data from the children not meeting the PTSD criteria were not analyzed fully. Instead, it was used to compare the differences in exposure levels to military trauma with the children meeting PTSD criteria and analyze the effect of the</p>
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				<p>analyze the effect of the initial PTSD status in the linear mixed models for the outcome measure.</p>	<p>initial PTSD status in the linear mixed models for the outcome measure.</p> <p>Significant age-by-time interaction was observed for the total depression score; negative self-esteem; interpersonal problems; anhedonia; and negative self-esteem indicating that improvements in depression and these subscales from baseline to follow-up were greater for older children.</p> <p>Overall depression and subscale scores significantly improved post-intervention and were fully maintained for interpersonal problems, negative self-esteem, and ineffectiveness subscales. Improvement was partially maintained for total depression score and subscales of anhedonia and negative mood.</p> <p>A limitation of this study was that large amounts of data were missing at follow-up. Significantly more girls followed up because many of boys had begun working and were unavailable.</p>
Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations



<p>Tan, Teo, Srivastava, Smith, Smith, Williams, &amp; Jensen 2013 Houston, Texas</p>	<p>Quasi-experimental design</p> <p>This study was designed to evaluate the possibility of an innovative treatment for women veterans living in rural areas who suffer from chronic pain and/or depression associated with trauma.</p> <p>This study chose to compare pretreatment and posttreatment self-reported measures to assess any changes that</p>	<p>34 female veterans</p> <p>Participants underwent 6 weeks of home practice with the Stress Eraser (SE) biofeedback device and kept a log that recorded their daily practice.</p> <p>Training was paired with weekly clinical video-conference (CVT) support sessions.</p> <p>Follow-up assessments were completed 6 weeks after the final</p>	<p>The independent variables were the SE device for biofeedback, and the CVT support sessions.</p> <p>The dependent variables included PTSD symptoms, depression symptoms, pain intensity and unpleasantness and sleep disturbance.</p>	<p>Cognitive Impairment was measured using the Short Orientation-Memory-Concentration Test of Cognitive Impairment.</p> <p>Psychopathology and/or substance abuse were measured with the Mini-International Neuropsychiatric Interview.</p> <p>PTSD symptoms were measured using the PTSD Check List – Civilian version.</p> <p>Depressive symptoms were measured using the Center for Epidemiological Studies Depression Scale.</p>	<p>Pain intensity did not significantly decrease from pretreatment to posttreatment, or pretreatment to follow-up. However, statistically significant improvements were found in pain unpleasantness, pain interference, depressive symptoms, PTSD symptoms, and sleep disturbance. Improvements appeared to be maintained at 6-week follow-up.</p> <p>Frequency of SE use was significantly associated with decrease in distressed mood and decreased anxiety, while SE points obtained was significantly associated with decrease in distressed mood.</p> <p>The sample of women veterans studied presented with multiple symptoms and issues, making them a challenging group to investigate.</p> <p>Given the small sample size of the current preliminary study, the power to detect significant treatment effects may have been reduced.</p> <p>This study did not seek to assess factors that can impact delivery and success of the treatment.</p>
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	could be associated with the intervention.	<p>session to detect improvements over a short period of time.</p> <p>Focus groups were conducted to determine the acceptability of the SE device and the CVT sessions.</p>		<p>Pain intensity and unpleasantness were measured using adapted versions of measures of sensory intensity and affective magnitude.</p> <p>Pain interference was measured using the Pain Interference Short Form of the Patient-Reported Outcomes Measurement Information System.</p> <p>Sleep disturbance was assessed using the Medical Outcomes Study Sleep measure.</p>	
Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations
Climov, Lysy, Berteau, Dutrannois, Dereppe,	randomized controlled study	<p>N = 24</p> <p>n = 13 (experimental)</p>	The independent variables were the cardiac	All measurements were obtained at the start of the programs for both	<p>Blood Pressure:</p> <p>There were no statistically significant differences between the control group and the biofeedback group in the</p>

<p>Brohet, &amp; Melin 2014 Brussels, Belgium</p>	<p>The purpose of this study was to investigate the feasibility of applying heart rate variability (HRV) biofeedback in order to increase the cardiac coherence level in coronary artery disease (CAD) patients participating in a cardiac rehabilitation program.</p>	<p>) n = 11 (control)  The experimental group participated in 10 sessions of cardiac coherence biofeedback training in addition to the rehabilitation program.  The control group only participated in the usual cardiac rehabilitation program.</p>	<p>coherence biofeedback training and the rehabilitation program.  The dependent variables consisted of physiological variables and psychosocial variables. The physiological variables were: systolic and diastolic blood pressures, and HRV. The psychosocial variables were: anxiety, depression, and type D personality.</p>	<p>groups and at the end of the programs 6 weeks later.  Blood pressures were taken with a mercury sphygmomanometer.  HRV was analyzed with a 24-hour ECG Holter monitor.  Anxiety and depression levels were assessed using the Hospital Anxiety and Depression Scale (HADS) questionnaire.  Emotional and social problems associated with type D personality were assessed a questionnaire.  Cardiac coherence</p>	<p>evolution of the systolic or diastolic blood pressure values over the course of the study.  HRV: The biofeedback group's standard deviation of the NN intervals (SDNN) increased in 5 patients, decreased in 4 patients and remained stable in 1 patient. This represents a 7% increase in HRV. The control group's SDNN increased in 4 patients, decreased in 3 patients and remained unchanged in 1 patient. This represents a relative increase of 5.7%.  Psychological Parameters: Score levels for depression and anxiety decreased slightly in the biofeedback group compared to the control group, but the difference was not statistically significant.  Cardiac Coherence: Most patients in the biofeedback group were able to increase their cardiac coherence percentage significantly.  All of the participants were male. The sample size was rather small. Lack of participation in the home practice. Biofeedback sessions were</p>
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				was calculated using the Freeze Framer system.	sometimes scheduled at different moments of the morning. Data were missing.
Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations
Canadian Agency for Drugs and Technologies in Health 2014 Canada	This study is a systematic review.  The purpose of this study was to update a previous summary of the evidence on the clinical effectiveness and safety of neurofeedback and biofeedback in the treatment of post-traumatic stress disorder (PTSD), generalized anxiety disorder (GAD), or	n = 3 reports total  n = 1 (PTSD study)  n = 2 (Depression studies)	Variables of interest included neurofeedback and biofeedback.	The quality of the included systematic review was assessed using AMSTAR. The quality of the included RCT was assessed using Downs and Black checklist.  Numerical scores were not calculated. The strengths and limitations of individual studies are summarized and presented.  Three studies were included in the review: One was a systematic review, one was an RCT, and one was a	No studies on the clinical evidence regarding the benefits and harms of neurofeedback for PTSD, GAD, or depression were identified.  No significant changes in PTSD symptoms were reported after biofeedback.  In the non-RCT, biofeedback had a beneficial effect on depressive symptoms in senior patients.  No evidence-based guideline were identified.  Only 3 studies were assessed. There were no studies identified for patients with GAD. Due to the limited number of biofeedback studies identified (n = 3) and the poor quality of the clinical trials, it is difficult to draw definitive conclusions regarding the clinical effectiveness and safety of biofeedback

	depression.			cohort study.	on PTSD and depression.
Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations
Kotozaki, Takeuchi, Sekiguchi, Yamamoto, Shinada, Araki, Takahashi, Taki, Ogino, Kiguchi, Kawashima  2014  Sendai, Japan	randomized, double-blind, controlled, crossover trial.  The aim of this study was to investigate the anatomical correlates of biofeedback effects and the psychological changes associated with those effects.	30  n= 15 (Intervention Group)  n= 15 (Control Group)  Participants in the intervention group underwent 4 weeks of biofeedback intervention sessions, while the control group went through normal everyday life	The independent variable was the biofeedback therapy that measured cerebral blood flow and heart rate.  The dependent variables were psychological changes, salivary cortisol levels, and gray matter structure changes.	Psychological effects were measured using the Center for Epidemiologic Studies Depression Scale (CES-D), the General Health Questionnaire 30, the Positive and Negative Schedule (PANAS), and the Brief Job Stress Questionnaire (BJSQ).  Saliva samples were collected for analysis of cortisol levels. MRI datum were collected using the 3T Inera Achieva MRI scanner and	<i>Psychological Measures:</i> The biofeedback group exhibited a significant decrease in the postintervention CES-D, PANAS-NA, and BJSQ tension, depression, and stressors of working environment scores; a significant increase in the BSJQ aptitude for the job scores was also exhibited.  The biofeedback group exhibited a significant decrease in salivary cortisol levels, indicating a greater reduction in stress in this group compared to the control group.  The biofeedback group showed a significant increase in the rGMV of the right lateral orbitofrontal cortex (OFC) and around the left subgenual anterior cingulate cortex (sgACC).  All of the participants were men. Middle-aged subjects may have been

		without an intervention for 4 weeks.		the voxel-based morphometry (VBM).	chronically exposed to stress and may have developed damage to some brain areas as a result.
Author(s), Year, Location	Study Design and Purpose	Sample Size	Research Variables	Data Collection	Key Findings and Limitations
Zwan, Vente, Huizink, Bögels, & Bruin 2015 Amsterdam, Netherlands	randomized controlled trial  The purpose of this study was to compare the effects of self-directed PA, MM, and HRV-BF on perceived stress, anxiety, depression, sleep quality and psychological well-being in adults with stress complaints.	75 adults  n = 23 (Physical Activity group)  n = 27 (Mindfulness Meditation group)  n = 25 (Heart rate variability biofeedback group)  A total of 19 participants dropped out after the pre-test, but before the intervention started.	The independent variables were physical activity, mindfulness meditation, and heart rate variability biofeedback.  The dependent variables were stress, anxiety, depression, sleep quality, and psychological well-being.  Physical activity (PA), mindfulness meditation (MM), and HRV	Measurements of depression, anxiety, and stress were conducted using the Dutch version of the Depression Anxiety Stress Scales (DASS).  Sleep quality was measured using the Dutch version of the Pittsburgh Sleep Quality Index (PSQI).  Psychological well-being was measured using the Dutch version of the Scales of Psychological Well-being (SPW).	The intervention group reported slightly better sleep quality at pretest than the dropout group. Psychological well-being at pre-test was lower in participants with missing data compared to those with data.  Stress, anxiety, depression, sleep quality, and psychological well-being all changed significantly in the expected direction over time. The PA intervention yielded the largest effects. MM was the only intervention that improved sleep quality. HRV-BF did not reduce depressive symptoms in contrast to the other interventions. Psychological well-being improved less in the HRV-BF group compared to other groups.  Participants who trained for approximately 70% of the prescribed time showed larger regression coefficients compared to the complete sample, indicating that greater compliance is associated with larger effects of the interventions.

			biofeedback (HRV-BF) were examined in relation to stress.		Long term effects were not assessed in this study. Missing data from participants makes it possible that the intervention effect may have been slightly overestimated. Self-report measures are sensitive to method variance or social desirability effects.
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